Anatomical and Clinical Outcomes after Endovascular Treatment for Unruptured Cerebral Aneurysms

A Single-Center Experience

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Summary

To describe the immediate and follow-up anatomical outcomes as well as procedure-related morbidity after endovascular procedures for unruptured cerebral aneurysms, we reviewed 68 patients with 78 unruptured aneurysms treated with detachable coils from may 1996 to february 2002. Angiograms were retrospectively reviewed for the nature of the aneurysms and the degree of therapeutic obliteration. Periprocedural complications, immediate clinical outcome and long-term neurological status were analyzed.

Immediate anatomical outcomes were complete in 35 aneurysms (45%); residual neck in 24 (31%), partial contrast filling in 17 (22%), and failed embolization in two (2%). Of 27 aneurysms with follow-up angiography, 12 of the 13 aneurysms that were completely occluded in the initial treatment were still completely occluded at the end of a mean follow-up period of 17 months. Periprocedural complications were thromboembolic (n = 6), haemorrhagic (n = 3), coil protrusion (n = 7) and other unrelated complications (n = 3). Only two patients, with thromboembolic complications were moderately disabled with permanent neurological deficits in immediate clinical outcome, and their condition improved to independent in 1.5 and three months each. Small aneurysms and posterior circulation location showed more protective immediate results than aneurysms of large and anterior circulation after endovascular treatment (p values: 0.01 and 0.02).

Our experiences of endovascular treatment for unruptured cerebral aneurysms were comparable to the results of recent series. Endovascular treatment for small posteriorly located aneurysms produced significantly better results than for large anteriorly located lesions.

Introduction

The endovascular treatment of unruptured cerebral aneurysms using the Guglielmi detachable coil (GDC) or detachable coil system (DCS) has become an alternative to surgery. Although there has been much controversy about which unruptured aneurysms should be treated [1–5], the rupture of a cerebral aneurysm may result in serious morbidity or mortality [6,7], so such ruptures demand therapeutic intervention to prevent fatal outcome.

Surgical outcomes of unruptured aneurysms have been variably reported in previous series, with morbidity rates of 1.4 - 12.1% and mortality rates of 0 – 3.8% [8-14]. This variability might result from incomplete information retrieval of these studies in terms of age, size and location of aneurysms, institutional treatment volume, and

development of surgical and medical management. In contrast to outcome in surgical series, permanent complications related to endovascular treatment ranged from 3.7% to 8% [15,16], with the mortality rate being less than 1% and with a tendency for no deaths in recent series [17]. Such results may be related to technological improvement. This improvement of technology and devices including the balloon-remodeling technique, improved delivery systems and advanced medical care has influenced anatomical and clinical outcome, even hospital charge, and hospital stay after endovascular treatment [18], to the extent that such techniques have become the primary treatment modality rather than surgery for unruptured aneurysms in our institution. In this study we describe our results in terms of procedure-related complications and permanent neurological deficits, related to endovascular treatment of unruptured cerebral aneurysms using detachable platinum coils.

Material and Methods

Sixty-eight patients with 78 unruptured cerebral aneurysms underwent endovascular treatment using GDCs alone (72 aneurysms), GDCs combined with DCSs (5 aneurysms), and DCSs alone (1 aneurysm), between may 1996 and february 2002. Forty-six patients were female (68%) and 22 male (32%), and ages ranged from 21 to 79 years with an average age of 53 years. Six patients (8%) were younger than 40 years of age, 65 (83%) were between 40 and 69 years, and seven (9%) were older than 70. Aneurysms were detected by four different ways: first, incidental detection during work-up for unrelated medical conditions such as cerebrovascular ischemia, headache, dizziness, or polycystic kidney disease (n = 40); second, cranial nerve symptoms by mass effect (n = 5); third, coincidental detection with acute subarachnoid haemorrhage (n = 17); fourth, coincidental detection with arteriovenous malformation or intracranial tumor (n = 6). Treatment options were discussed for all patients by vascular neurosurgeons and interventional neuroradiologists, with a consensus leading to endovascular treatment being made in 56 patients. In the others, endovascular treatment was performed due to refusal of surgery (n = 9), poor medical condition and old age (n = 1), and attempted surgery (n = 2).

Sixty-five (83%) and 13 (17%) aneurysms were located in the anterior and posterior circulations, respectively. Paraclinoid internal carotid artery (ICA) aneurysms were the most common of all (42%). Aneurysmal locations are summarized in table 1. Aneurysms were distributed according to the following size categories: 67 small aneurysms (≤ 10 mm), 11 large aneurysms (11 to 24 mm), and no giant aneurysms. Necks were considered narrow (≤ 4 mm) in 56 aneurysms (72%) and wide (> 4 mm) in 22 (28%). As for the combination of size and neck, 54 aneurysms (69%) were small size and narrow neck, 13 (17%) small size and wide neck, two (3%) large size and narrow neck, and nine (12%) large size and wide neck.

The procedures were performed under intravenous general anesthesia and systemic heparinization except for coincidental cases with acute subarachnoid haemorrhage (SAH) in which a half dose of heparin was given after the insertion of a few initial coils. If the coil mass did not compromise a parent artery or thromboembolic complication did not develop, the heparinization was stopped at the end of the procedure. In eleven aneurysms, comprising five wide necks and six narrow necks, the procedure was assisted with an occlusion balloon catheter (Sentry, Boston Scientific, USA) or latex detachable balloon (Debrun balloon, Cath-Net Science, France). In three aneurysms, another microcatheter was used to prevent protrusion of the coil loop into the parent arterial lumen.

Anatomical results were strictly evaluated on immediate and follow-up angiography with multiple projection and if present, 3-D angiography.

The results were classified as one of the following: “complete occlusion”, which was defined as no contrast filling at any aneurysmal portion; “residual neck”, which was defined as residual filling of part of the aneurysmal neck with longer width than depth; “intra-aneurysmal contrast filling”, which was defined as contrast filling of the neck into the sac with longer depth than width, or within the coil mesh or in the perimeter apart from the parent artery; and “attempted occlusion”, which was defined as attempted when embolization could not be performed. This angiographic evaluation was determined mainly according to the classical method but differed with respect to its clear de-

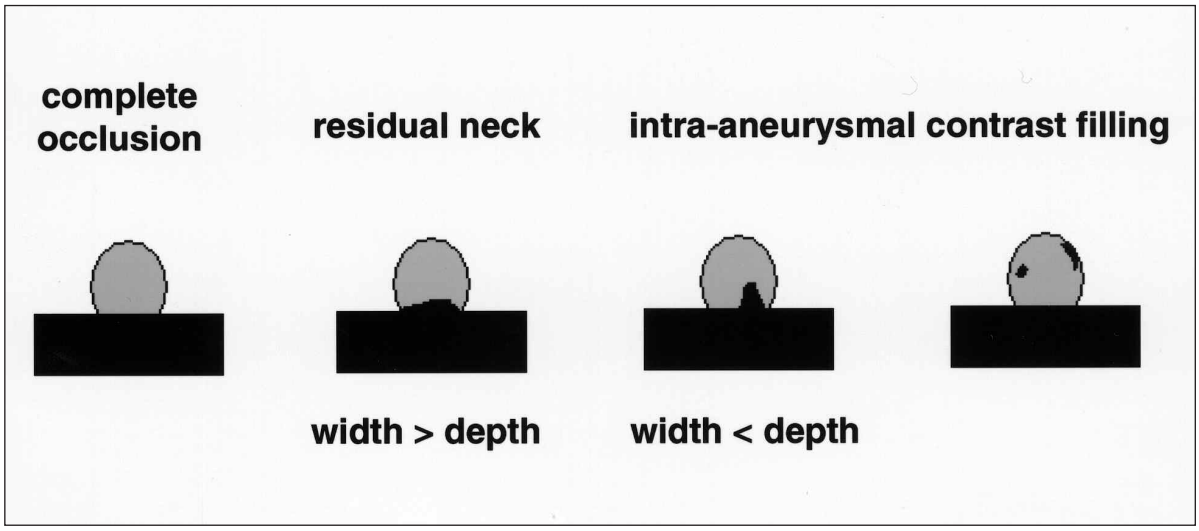

Figure 1 Diagrams of three types of immediate anatomical result.

finition for the residual neck and intra-aneurysmal contrast filling (figure 1). If complete occlusion or small residual neck was achieved, routine follow-up examinations were recommended by six months MR angiography and one year conventional angiography. However, follow-up intervals were variable and many patients were even lost, probably resulting from the study population being mainly composed of incidental aneurysms. Twenty-four patients with 27 aneurysms underwent at least one follow-up conventional angiography (0.75 - 42 months interval, mean: 11.2), of whom eight patients with ten aneurysms underwent a second follow-up angiography (5 - 38 months interval, mean: 30.6).

Clinical results included periprocedural complications, and immediate (at discharge) and follow-up clinical outcomes were rated according to the Glasgow outcome scale[19]. Immediate outcome was based on the discharge summary with a specific form of neurovascular care in all patients, and follow-up outcome on the outpatient records filled with neurological changes in 62 patients (0.5 - 60 months interval, mean: 13). The remaining six patients were lost to follow-up. The subgroup characteristics of age, location, size, and neck width were compared with the three categories of the immediate anatomical result (complete occlusion, residual neck, and intra-aneurysmal contrast filling combined with attempted occlusion). The χ^2 test was performed using SPSS 7.5 Windows software for statistical evaluation.

Table 1 **Location of 78 unruptured aneurysms in 68 patients**

Locations	Numbers (%)
anterior circulation	*65 (83)*
ICA - paraclinoid	33 (42)
ICA - PCoA or AChA	9 (12)
ICA - bifurcation	3 (4)
ICA - cavernous	2 (3)
MCA	13 (17)
ACoA	4 (5)
ACA	1 (1)
posterior circulation	*13 (17)*
Basilar bifurcation	6 (8)
SCA	3 (4)
PCA	3 (4)
PICA	1 (1)
Total	*78 (100)*

ICA, internal carotid artery; PCoA, posterior communicating artery; AChA, anterior choroidal artery; MCA, middle cerebral artery; ACoA, anterior communicating artery; ACA, anterior cerebral artery; SCA, superior cerebellar artery; PCA, posterior cerebral artery; PICA, posterior inferior cerebellar artery.

Results

Anatomical Results

Immediate postembolization angiography showed complete occlusion in 35 aneurysms (45%), residual neck in 24 (31%), intra-

aneurysmal contrast filling in 17 (22%), and attempted occlusion in two (3%). Of 27 aneurysms with at least one follow-up angiography, complete occlusion was noted immediately in 13 aneurysms. Of these 13, the occlusion changed into residual neck in only one at 12 months postembolization (figure 2), while in the other 12 it was still unchanged at the end of follow-up ranging from four months to 42 months postembolization (mean: 17 months). Nine aneurysms with immediate result of residual neck changed into various degrees of obliteration on follow-up angiography: enlarged (figure 3) in three aneurysms at 12, 27, and 30 months postembolization, unchanged in two aneurysms of a patient sequential at 15 and 38 months postembolization; decreased in two aneurysms at nine and ten months postembolization, and occluded in two aneurysms sequential at three and 12 months, and at five and 36 months postembolization. Five aneurysms with immediate result of intra-aneurysmal contrast filling also demonstrated various patterns of changes on follow-up angiography: completely occluded (figure 4) in one aneurysm with previous contrast filling of perimeter at six months postembolization; and unchanged or enlarged in four aneurysms with previous contrast filling of neck and deeper portion, at one, six, seven and nine months postembolization respectively.

Clinical Results

Periprocedural complications were divided into four categories: thromboembolic, haemorrhagic, coil protrusion, and others. These are summarized in table 2. Of the patients with thromboembolic complication (n = 6), compromise of a parent or branching artery was detected during the procedure in four patients, for whom intra-arterial thrombolytic or antiplatelet agent with wire manipulation was performed to achieve partial or good recovery angiographically. However, motor aphasia developed in one patient and showed almost complete improvement three months later (case 2). One patient had a permanent deficit of hemianopsia resulting from unilateral PCA territory infarction after endovascular treatment of a basilar tip aneurysm and clipping of an anterior communicating artery aneurysm five days after embolization (case 4). The infarction was thought to be a manifestation of delayed embolic complication of endovascular treatment of the posterior circulation aneurysm. One patient with an anterior communicating aneurysm had no neurological change in spite of the development of ipsilateral ACA occlusion during the procedure (case 6).

Haemorrhagic complication occurred during coil deposition in one patient with a proximal posterior cerebral artery lesion associated with a giant arteriovenous malformation in its territory, and on the following day in two more patients with large ICA lesions. There was no angiographic evidence of aneurysmal rupture but CT showed SAH in all patients. Two patients received conservative treatment and one underwent external ventricular drainage due to hydrocephalus after reversal of heparinization with protamine sulfate and rapid completion coiling; new or worse neurological deficits did not develop in these three patients.

Although coil loop protrusion to the parent artery occurred in seven patients, no significant events such as coil migration or arterial compromise occurred. In one patient, recovery from general anesthesia was delayed due to massive sedation, and there was clinical and laboratory evidence of hepatic congestion and pulmonary oedema (case 17). In this case, a long hospital stay was needed to treat these unrelated complications, and chronic insertion of urinary catheter resulted in urinary difficulty with urethral stricture, while other problems were completely resolved. Two patients suffered another complication in addition to procedure-related thromboembolism and coil protrusion namely pulmonary thromboembolism (case 6) and pulmonary oedema (case 15), which were both resolved by conservative treatment. Two patients died of unrelated causes: one was acute myocardial infarction during rehabilitation and the other was rupture of a contralateral giant aneurysm for which surgery was attempted 20 days after endovascular treatment of a left paraclinoid aneurysm. Of all complication cases (25%), two patients experienced new or worse neurological deficits after the procedure (cases 2 and 4).

After endovascular treatment, small posterior circulation aneurysms had more protective results including complete occlusion and residual neck, than large anterior circulation aneurysms (table 3). Age and neck were not

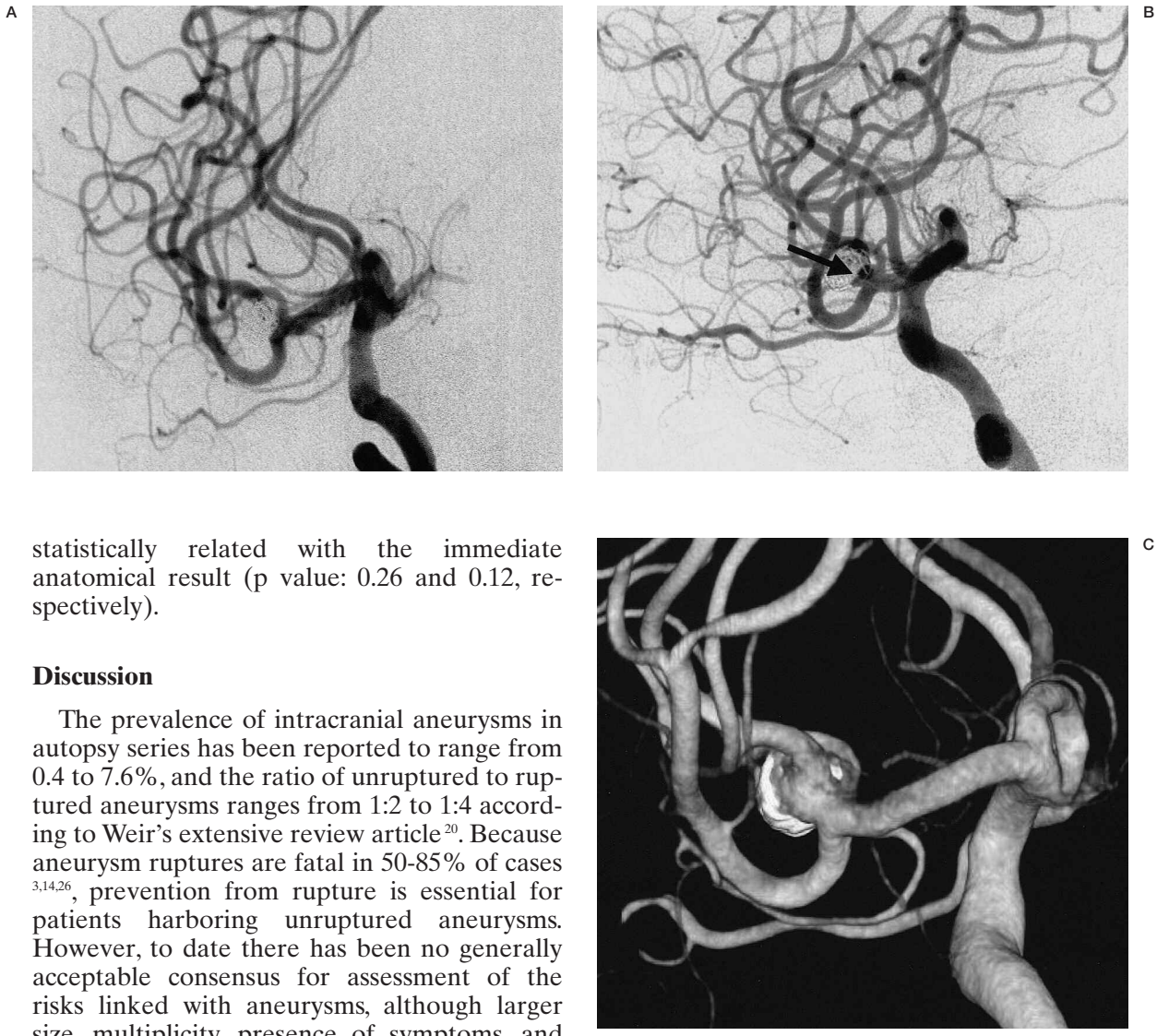

Figure 2 Recanalization of a completely occluded aneurysm. Immediate postembolization angiography (A) shows complete occlusion of the aneurysmal sac of the right MCA trifurcation. On twelve months follow-up angiography (B), the coil mass is compacted and the aneurysmal neck re-opened (arrow), which is clearly visualized on 3-D angiography (C).

statistically related with the immediate anatomical result (p value: 0.26 and 0.12, respectively).

Discussion

The prevalence of intracranial aneurysms in autopsy series has been reported to range from 0.4 to 7.6%, and the ratio of unruptured to ruptured aneurysms ranges from 1:2 to 1:4 according to Weir's extensive review article [20]. Because aneurysm ruptures are fatal in 50-85% of cases [3,14,26], prevention from rupture is essential for patients harboring unruptured aneurysms. However, to date there has been no generally acceptable consensus for assessment of the risks linked with aneurysms, although larger size, multiplicity, presence of symptoms, and younger age tend to be associated with greater risks [20]. Furthermore, there has been much debate about the annual rupture rates of unruptured aneurysms. The preliminary results by investigators for the ISUIA [14] of a much lower rupture rate (0.05% in small aneurysms without prior SAH) has raised many arguments for the annual rupture rates, which have been well described in Editorials in the *Journal of Neurosurgery* [21-25]. We must acknowledge that the differences in reported rupture result mainly from selection bias and different sample sizes. With the ongoing accumulation of patient records, further follow-up data and analyses of both the retrospective and prospective cohorts can be expected.

Neurosurgeons or interventional neuroradiologists must weigh the consequences of the natural course of unruptured aneurysms, and posttreatment morbidity and mortality prior to treatment. In the light of our experiences with the natural course of unruptured aneurysms, we thought that the recommendations from the Stroke Council of the American Heart Association could serve as a framework of guidelines for the treatment of aneurysm as the authors acknowledged [27], after which the treatment op-

tion should be determined. Surgical treatment for unruptured aneurysms has been actively performed since the early 1970s and has fairly clearly defined morbidity and mortality, as discussed in the introduction. In the most exhaustive meta-analysis, Raaymakers et Al [12] reported that the postoperative mortality rate for intracranial operations in 2460 patients with unruptured aneurysms was 2.6% (95% CI 2-2.3%), with a tendency to decrease in recent times, and the postoperative morbidity rate was 10.9% (95% CI 9.6-12.2%). The results of the prospective arm of the ISUIA [14] were higher than these (mortality: 3.8%, morbidity: 12.1%); a deviation that was largely ascribed to the different assessment times in mortality and additional inclusion of impaired mental status in the assessment of morbidity, as pointed out by Wardlaw [28].

The effectiveness and risks of endovascular treatment are less certain because the treatment is constantly being refined and additional experience is being gained. For example, in the report by Murayama et Al [17] of eight postprocedural complications, seven occurred between 1991 and 1995 but only one occurred during the next four years. Therefore deterioration from procedural complications occurred in 4.3% of cases. In another systematic review [15], the morbidity rate was just 3.7%. Although the morbidity rate of endovascular treatment is clearly lower in recent large series than that of surgery, direct comparison of the ratio is inappropriate because of different patient population subgroups, and different standards and times for assessment. However, in three multicenter or single center studies [16,18,29], either adverse outcomes (in-hospital deaths and discharges to nursing homes or rehabilitation hospitals), or new or worse outcomes according to the Rankin Scale Score [12] occurred in 18.5%, 25% and 25% of surgically treated cases, and 10.6%, 10% and 8% of endovascularly treated cases. These results support endovascular treatment as an option for an incidental aneurysm, although postembolization recanalization remains a problem. Malisch et Al [30] reported that rebleeding rates after endovascular treatment were 0% for small aneurysms, 4% for large ones, and 33% for giant lesions at midterm (≥ 2 years). In a study of midterm angiographic outcome [31], the recanalization rates of first, second, and third year postembolization were progressively decreased (28%, 20% and 14%). Recanalization and rebleeding rates increased with larger aneurysms and more incomplete results.

In our study, the rates of complete occlusion and residual neck of the immediate angiographic results (45% and 31%, respectively) were comparable with the results (47 - 63% and 27 - 42%, respectively) of other studies [17,32,33]. The rate of intra-aneurysmal contrast filling (22%) in our study was much higher than the rate of residual aneurysm or sac or body filling (equivalent to residual aneurysm) in the previous studies (4 - 5%), but was lower than the result (38%) of Ng et Al [31], in whose study the rate of the residual neck was as low as 16%. This discrepancy may be ascribed to subjective determination of the degree of obliteration and equivocal discrimination between residual neck and residual aneurysm. In cases of small contrast filling between coil interstices or in the perimeter, and deeper filling from the neck, we categorized them as intra-aneurysmal contrast filling that is similar to the residual aneurysm cases of other studies without clearly mentioning the discrimination between residual neck and residual aneurysm. These objective methods probably greatly increased the rate of intra-aneurysmal contrast filling. In our experiences of endovascular treatment for ruptured and unruptured aneurysms, the small contrast filling between coil interstices without visible empty space disappeared spontaneously in most cases. One of the five cases of intra-aneurysmal contrast filling with follow-up angiography did show a small crescent-shaped contrast filling in the perimeter immediately and total occlusion at six months postembolization in our study, while the other four cases immediately showed deeper contrast filling from the neck, and were unchanged or enlarged in contrast filling on follow-up angiographies. The result by Ng et Al of progressive resolution of the residual aneurysms on follow-up angiography (44% within a year and 30% within two years) may support this phenomenon. Therefore this clear method of discrimination between residual neck and residual aneurysm, which can even discriminate between residual aneurysms themselves, is needed to evaluate the postembolization angiographic results. Furthermore, small intra-aneurysmal contrast filling between coil interstices or in the perimeter, without empty

Table 2 **Summary of unexpected events in endovascular treatment for unruptured cerebral aneurysms**

Events	Case No.	Age	Location	Size	Neck	Imm.	FU outcome*
Thromboembolic (8.8%)	1	70	PCA	3	narrow	1	1 & 1 (1 & 4 months)
	2	66	MCA	5	wide	2	1 (3 months)
	3	45	ICA-AChA	3	narrow	1	1 & 1 (1 & 3 months)
	4	56	BaB	3	narrow	2	1 & 1 (1.5 & 24 months)
	5	65	BaB	8	narrow	1	-
	6	62	ACoA	6	narrow	1	1 & 1 (1 & 28 months)
Haemorrhagic (4.4%)	7	48	ICA-PC	22	wide	2	1 & 1 (1.5 & 8 months)
	8	42	PCA	3	narrow	1	1 & 1 (1.5 & 40 months)
	9	64	ICA-PC	20	wide	1	1 & 1 (1.5 & 7 months)
Coil protrusion (10.3%)	10	36	ICA-PC	8	narrow	2	1 & 1 (2 & 28 months)
	11	55	MCA	7	narrow	3	3 (1 month)
	12	53	ICA-PC	12	wide	1	1 & 1 (0.25 & 4 months)
	13	61	ICA-PC	8	narrow	1	1 & 1 (0.25 & 4 months)
	14	65	ICA-PC	9	wide	5	-
	15	69	ICA-PCoA	5	narrow	1	1 & 1 (1.5 & 2 months)
	16	45	ICA-PC	7	wide	1	1 & 1 (0.75 & 8 months)
Others** (4.4%)	17	76	ICA-PCoA	4	narrow	2	2 (1 month)
	6	*62*	*ACoA*	*6*	*narrow*	*1*	*1 & 1 (1 & 28 months)*
	15	*69*	*ICA-PCoA*	*5*	*narrow*	*1*	*1 & 1 (1.5 & 2 months)*

*Size, long diameter in mm; Imm., immediate outcome in Glasgow outcome scale (GOS), new or worse disability (GOS) in box; * follow-up outcome in GOS and times in months; ** complications related with anesthesia or other unrelated medical procedure, patients with two kinds of complication printed in italic ; BaB, basilar bifurcation; ICA-PC, paraclinoid ICA.*

Table 3 **Factors related to immediate anatomical outcome (%)**

Immediate anatomical outcome	Location		Size	
	anterior	posterior	≤ 10 mm	11-25 mm
complete occlusion	25 (39)	10 (77)	34 (51)	1 (9)
residual neck	21 (32)	3 (23)	20 (30)	4 (36)
aneurysmal contrast filling	17 (26)	0	11 (16)	6 (55)
attempted embolization	2 (3)	0	2 (3)	0
Total	***65 (100)***	***13 (100)***	***67 (100)***	***11 (100)***
p-value	*0.02*		*0.01*	

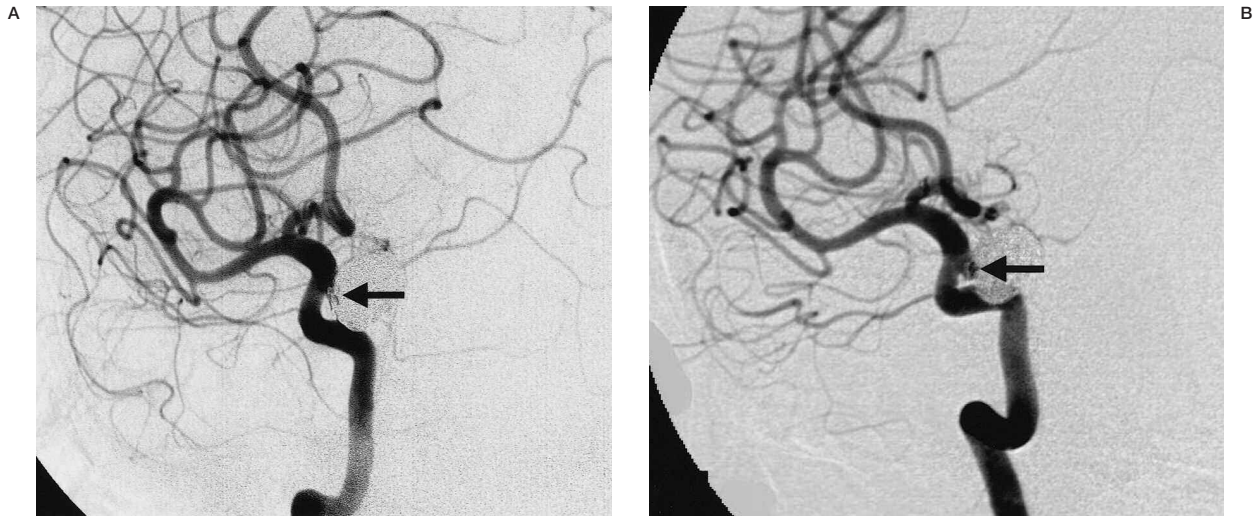

Figure 3 Recanalization of an aneurysm with residual neck. A large paraclinoid aneurysm was embolized with an immediate postembolization result of small linear contrast filling at the neck portion (A), which is enlarged to be a small saccular contrast filling (arrow) with compact modification of the coil mass on 12 months follow-up angiography (B).

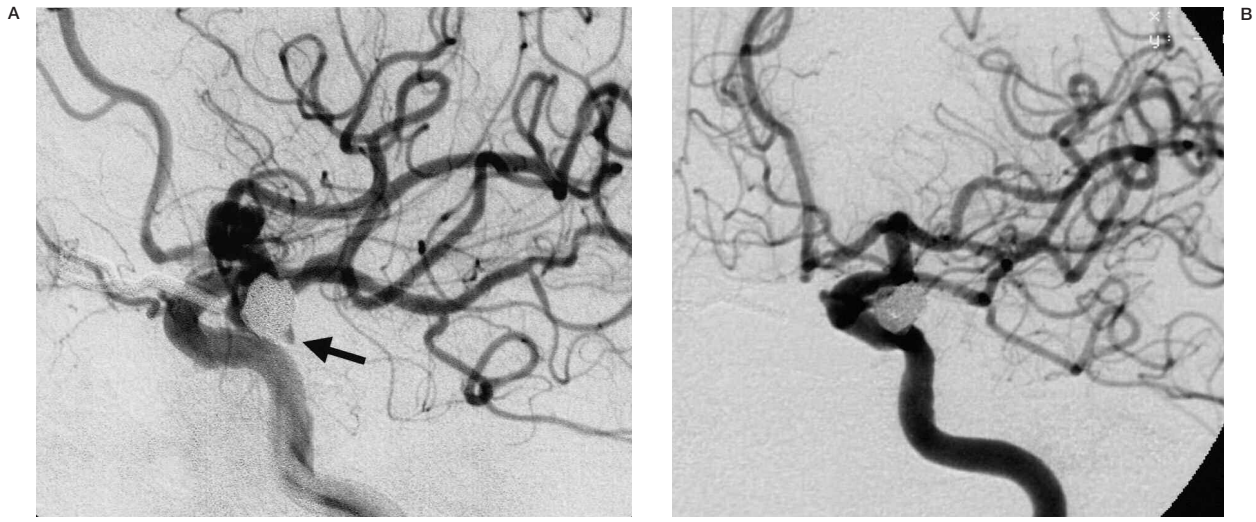

Figure 4 Complete occlusion of residual contrast filling on follow-up. This 71-year-old woman had suffered from subarachnoid haemorrhage and underwent clipping of the right ICA aneurysm. Another incidental aneurysm of the left ICA was embolized and immediate postembolization angiography (A) shows with a triangular-shaped contrast filling in the perimeter of the aneurysm (arrow). Six months follow-up angiography (B) shows complete occlusion of previously demonstrated contrast filling space.

space, is possibly insignificant, although more research focusing this issue is required for confirmation.

Of the 13 cases of complete occlusion with at least one follow-up angiography in our study, most (n = 12) were still occluded at the end of the follow-up (4 - 42 months). Only one case (8%) was recanalized to residual neck at 12 months postembolization. Recanalization rates of completely occluded aneurysms ranged from 0% to 23% in previous studies [17,31,33], a variability that may be attributed to the use of soft coils, the increased frequency of coiling in recent series, the effect of heparinization on immediate angiographic results and different follow-up intervals. Even completely occluded aneurysms should be checked within three years because two studies have reported that aneurysms com-

pletely occluded at six to 12 months postembolization were recanalized at two or more years postembolization (14%), and ruptured at 18 months postembolization [31,34].

Evolution of residual neck as an immediate postembolization result has been well described in the study by Hayakawa et Al [35], in which 49% of aneurysms exhibited recanalization, 26% remained unchanged and 25% displayed progressive thrombosis on follow-up angiography (mean: 17.3 months). In small aneurysms with wide necks, large aneurysms, and giant aneurysms, the rate of recanalization was significantly higher than in small aneurysms with narrow necks (42%, 87% and 90% vs. 17%, respectively). Our study also revealed various changes: enlarged, 33%; unchanged, 22%; and decreased or occluded, 44%. The lower rate of recanalization may be related to the absence of giant aneurysms in our study. Our results were comparable to those of the study of Murayama et Al [17].

Periprocedural complications in our results (n = 17, 25%) were thromboembolic (8.8%), haemorrhagic (4.4%), coil protrusion (10.3%) and others (4.4%). Of these, the cases of coil protrusion did not develop any anatomical or clinical problems on follow-up examinations, as opposed to coil migration, which did not occur in our series. Exclusion of the coil protrusion made thromboembolic the most common of all complications. Of the patients with thromboembolic complication, permanent neurological deficits (one each of motor aphasia and hemianopsia) developed in two patients in spite of intra-arterial thrombolytic therapy.

Three patients with haemorrhagic complication had no neurological sequelae, whereas one patient with other unrelated complication had chronic urinary difficulty with stricture due to prolonged insertion of urinary catheter. Hence, our clinical outcomes revealed a permanent neurological deficit rate of 3% along with good recovery at 1.5 and three months follow-up according to the Glasgow outcome scale [19]. In the studies including clinical results after endovascular treatment of unruptured aneurysms [17,33], thromboembolic complication was the most frequent and critical of all complications (5 - 8%), and permanent neurological deficits were caused in 4 - 6.5%. In terms of clinical outcome, our results were acceptable in comparison with the surgical and endovascular results of other institutes. The immediate clinical outcome after haemorrhagic complication was unchanged in all patients, in contrast with the 40% mortality rate of a previous study [36] where all patients with ruptured posterior circulation aneurysms died. The lack of cases with massive haemorrhage that can be demonstrated on angiography in our series may be one of the reasons why clinical deterioration did not occur after the treatment.

In our study, an immediate protective result including complete occlusion and residual neck was accomplished in a larger proportion of small size (81%) and posterior location (100%) than of large size (45%) and anterior location (71%), and this variance was statistically significant. Roy et Al also found a higher association between small aneurysms and narrow neck with total occlusion as a degree of obliteration [33], but the aneurysmal location and the patient's age were not statistically associated with the degree of obliteration in their study. Whilst we could not clearly explain this discrepancy, the higher percentage of small aneurysms (86%) with the resultant higher percentage of narrow-necked aneurysms (72%) might affect the result through selection bias, and balloon-remodeling and catheter-protective techniques might also have affected the nonsignificant relationship between neck size and anatomical results in our study. In contrast to the poor surgical result in the aneurysms of the posterior circulation, endovascular treatment can be relatively easily achieved via straight course and has therefore been selected as the treatment option for posterior circulation aneurysms. Our result of a higher protective degree of obliteration in the posterior circulation aneurysm indicates that endovascular treatment is more appropriate for such aneurysms.

In conclusion, our experiences of endovascular treatment for unruptured cerebral aneurysms were comparable to the results of recent series. Procedure-related complications were thromboembolic (8.8%), haemorrhagic (4.4%), coil protrusion (10.3%), and others (4.4%). Although permanent neurological deficits occurred in 3% of the patients, the condition of these patients eventually improved to allow them to function independently in daily life. Endovascular treatment for small posteriorly located aneurysms produced significantly better results than for large anteriorly located lesions.

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